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<s>Oral Surgery

<t>IDBs Versus Infiltration Dentistry: Is it time for change?

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<a/c>**Abstract:** Dentistry is unique in that high volume surgery is undertaken efficiently on conscious patients, an anathema to most other surgical specialties who predominantly operate on unconscious patients. Local anaesthesia provides an efficient block to nociceptive pain (the first stage of the pain pathway) but only addresses one small part of the pain experience. Currently the inferior dental block (IDB) is the 'go to' standard for dental LA for mandibular dentistry despite its significant shortcomings. Unfortunately, as creatures of habit we continue to practise what is taught to us at dental school, IDBs, when evolving more patient safe practice takes considerable time to be taken up by the workforce.

Local anaesthesia blocks are inefficient in providing swift pulpal anaesthesia. Malamed stated that the rate of inadequate anaesthesia ranged from 31% to 81%. When expressed as success rates, this indicates a range of 19% to 69%. These numbers are so wide ranging as to make selection of a standard for rate of success for IANB seemingly impossible. LA blocks also increase the risk of systemic complications and they are associated with nerve injury. Though LA-related permanent nerve injury is rare (approximately 1 in 52-7K IDBs), once the injury occurs approximately 75% may resolve but the remaining 25% are untreatable. Most patients with trigeminal nerve injuries experience chronic pain in their lip, teeth and gums or tongue and gums, depending on which nerve is damaged. This is a lifelong burden that these patients find difficult to accommodate, especially when they were never warned about the possible risk.

The risk of nerve injury can be mitigated by altering the block technique or by avoiding block anaesthesia altogether. With novel development in pharmacology of LA and equipment, block anaesthesia is likely to become rarely needed in dentistry.

<a/c>**CPD/Clinical Relevance:** Dentistry is a profession predicated upon causing and or managing pain in patients. Providing effective pain control during surgery is essential but using techniques with the minimum risks is imperative.

<ch1/1>So how can we improve our local anaesthetic practice?

There are four questions that we should first address in critiquing existing LA practice and assess if there is need for improvement.

1. What is the role of LA in managing analgesia for dental patients?

- An update on pain
- The patients' perspective

2. How do we minimize systemic complications of dental LA?

- Systemic issues for LA

3. What are the medical modifiers for dental LA?

4. How do we minimize regional complications of LA?

- Avoiding failed LA
- Avoiding local complications including LA nerve injuries

How can we do better? Proposed tailored smart LA practice:

- What technique?
- What Agent?
- What LA volume?

<ch1/1>What is the role of LA in managing analgesia for dental patients?

Patients want two main outcomes when they visit a dental practice, first pain free injections and second painless procedures.¹ However, needles and tablets are but a small part of the holistic pain management of dental patients.² The definition of pain is that it is '*an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage*'.³ The brain overlays the pain sensation on the part of the body that's getting hurt to protect it from harm. There are four types of pain:⁴ two healthy and two pathological. Healthy protective pain includes firstly; nociceptive pain, which is the conversion of tissue injury and release of algogenic factors (intracellular components released due to cell damage) which act as 'foreign bodies' exciting pain receptors on nociceptive nerve fibres (C, A

delta and A beta fibres). These cause transduction from chemical inflammation into an action potential and the progression of an action potential advancing up to the tertiary order neurones to the somatosensory cortex; once reached the 'ouch' is acknowledged resulting in reflex withdrawal of the digit from danger. Inflammatory pain follows nociceptive pain, if tissue damage occurs promoting tissue healing. This process should usually resolve in days or weeks, depending on the degree of damage and persistence of infection.

Local anaesthesia blocks nociceptive pain very successfully but, due to pain multiple components there is increasing evidence supporting the education of patients in expected pain levels (managing their expectations), being caring, empathetic, providing appropriate anxiolysis, distraction and, on occasions, providing this alone is not enough to manage perioperative pain in patients. Some patients may be stoic types ('rugby player') able to cope with the anticipated and actual surgical discomfort, whereas others may be more susceptible to lack of coping and catastrophizing ('football player patients') needing a lot more attention. Holistic patient management is all important in pain management, with alternative techniques (hypnosis and acupuncture).

The patients' expectations are paramount and it is known that all patients expect pain when visiting their dentist.⁵ It is important for clinicians to point out to patients that they are not magicians but surgeons and it is impossible to do complex surgery on patients without causing some minor discomfort intra-operatively and, occasionally, moderate pain post-operatively. Perioperative dental pain is not managed well in dentistry and is the most common adverse event reported by dentists^{6,7} and by patients.⁸ Regarding the dental experience involving pain, 60% of a representative sample of the general population aged 15 years or more has reported pain at least once during a dental visit.⁹

Local anaesthetic injection plus analgesic tablets are NOT enough! Local anaesthesia is only a small part of operative pain management.² Pain and its management is complex as the individual's pain experience is unique and based upon his/her gender, beliefs, religion, ethnicity, prior pain experience, psychological factors, nocebo and placebo

effects etc.⁵ There are many psychological factors driving the response to acute pain related to surgery and in relation to the development of chronic post-surgical pain.

The key aspects for operative pain management include:

- Patient factors including:
 - Managing the patients' expectations and anxiety. Education about pre- and post-operative events with clear and frank two-stage consent allowing patients some control of their treatment decisions;
 - Appropriate anxiolysis (assessment and management) will elevate pain thresholds and improve pain management.
- Medical aspects including:
 - Optimal Local anaesthetic practise;
 - Appropriately prescribed analgesics.
- Surgical factors: It is also acknowledged that good surgical practice minimizes pain for the patient, including minimal access technique.
- Post-op advice with accessibility for patient contacting the practice and/or surgeon with clear post-operative advice on mouthcare maintenance and analgesics use.

<ch1/1>How do we minimize systemic complications of dental LA?

Over one billion dental local anaesthetic injections are given annually worldwide (pers communication: Malamed S, FDI lecture 2017). The reported adverse reaction rate is 1:1,000,000 and the mortality (death) rate from dental local anaesthetic injections has been stated at 0.000002%. Allergies are very rare and can often be psychosomatic.¹⁰

The definition of the term 'adverse reaction' covers noxious and unintended effects resulting not only from the authorized use of a medicinal product at normal doses, but also from medication errors and uses outside the terms of the marketing authorization, including the misuse and abuse of the medicinal product. The range of pharmaceuticals used in dental practice is relatively small, consisting primarily of sedatives, local anaesthetics, analgesics and antibiotics. Adverse drug reactions are categorized as type A or type B.

- Type A reactions are more common and are generally attributable to known pharmacological or toxic effects of the drug.
- Type B reactions are idiosyncratic, unpredictable, acute/sub-acute, not related to a known mechanism

The most common adverse reactions to LA include:

- **Vasovagal** attack or faint: nearly all patient-related collapses during dental LA are faints. A study carried out at Dundee Dental School showed that of 27 cases of 'local anaesthetic allergies' only one was caused by the anaesthetic injection (and this was a sulphite allergy, not a drug allergy).¹¹ This can be overcome by good chairside manner and observation of the patient. If a prolonged procedure is anticipated, the patient should have eaten prior to the procedure or be provided with a glucose drink. Any patient who is anxious must be provided with suitable anxiolysis.
- **Allergy** to local anaesthetic agents is very rare and usually related to adjunctive agents including bung (Latex),¹² the preservative (sodium metabisulphites), antiseptic, vasoconstrictor or, very rarely, the local anaesthetic agent. Most LA agents are now latex free. Esters are highly allergenic and there are no documented allergy to amides. The patient is more likely to be allergic to bisulphate preservative (needed for vasoconstriction). The least allergenic LAs are Mepivacaine or plain Prilocaine. Allergy is not dose dependent unlike toxicity.¹³ The signs of allergy include breathlessness, disorientation and distress, urticaria hypotension and collapse. Immediate action is required including; Call for help, 1:1000 Units Epinephrine IM and provision of Oxygen.
- **Adverse effects** (Table 1) usually caused by high plasma concentration of LA drug resulting from:
 - Inadvertent intravascular injection related to block injections;
 - Excessive dose or rate of injection;
 - Medically compromised patients:
 - Delayed drug clearance;
 - Drug interactions.

Adverse events happen in relation to the concentration and dose of LA. Size and health of your patient and essentially intravascular injections which are more likely with block, intraosseous and periodontal injections. Minimizing risk of overdose includes avoiding:

- All 4 quadrant treatment (staged treatment for elderly patients);
- Plain LA (no vasoconstrictor);
- Full cartridge injections (should commonwealth move to 1.7 ml cartridges?);
- Exceeding maximum recommended dose (Table 2)

Young and elderly patients must be suitably assessed for their weight. A child of 5 years weighs 18–20kg – maximum dose 88 mg (2 x 2.2 ml lidocaine cartridges). Due to their size children are at high risk of toxicity. Goodson and Moore have documented catastrophic consequences of this drug interaction in paediatric patients receiving procedural sedation, along with excessive dosages of local anesthetics.¹⁴

Medical issues: Any health aspects that include metabolizing or excreting. The main medical risks are:

- Patients with cardiovascular diseases;
- Patients with endocrine diseases;
- Patients with CNS disorders;
- Patients with lung diseases.

Aspiration during dental LA is a legal requirement in the UK. Avoiding intravascular LA is possible by avoiding injection intra-vascularly by using aspiration and avoiding intraosseous injections and being aware of the increased vascularity of inflamed tissue whilst always observing clinical reactions by:

- Talking to patients during the injection and monitoring their ECG/blood pressure to realize early symptoms of central-nervous and cardiovascular toxicity if they are at risk;
- Stop injection immediately when early symptoms are realized;
- Consider the time course for development of toxic signs (5–10 min)
- Avoiding long-acting and potent substances (Bupivacaine is the most neurotoxic agent).

A recent survey of 2731 patients undergoing LA for dental treatment reported that 45.6% patients had medical risk factors (mostly cardiovascular). The overall LA complication rate was 4.5% complications (5.7% in risk patients/ 3.5% non-risk patients), which were most commonly dizziness, tachycardia, agitation and bronchospasm. Severe complications including seizures and bronchospasm occurred rarely (0.07%). Overall, there were less complications with articaine 4% I:100K epinephrine compared with articaine 4% I:200K epinephrine.¹⁶ articaine is less toxic than lidocaine at the same concentration as it has high binding plasma rate reducing crossing the placenta or blood brain barrier. Metabolism of articaine occurs in tissue and plasma (rather than in the **over???** for lidocaine or bupivacaine) and lidocaine only 50% is degraded after 1.5–3 hours which is much slower than articaine of which 50% is eliminated after 20 minutes (Table 3).

All suspected adverse events to local anaesthesia should be reported and this can be done online via the MHRA Yellow Card website (at www.mhra.gov.uk/yellowcard) or by calling the National Yellow Card Information Service on 0808 100 3352 (10am to 2pm Monday–Friday). In addition, dental practices should sign up to receive MHRA alerts. Subscribe using the following link: <https://www.gov.uk/drug-device-alerts/email-signup>

<ch1/1>What are the medical modifiers for dental LA?

There are very few absolute medical contra-indications to local anaesthetic and these are listed in Table 4. There are some relative but not absolute contra-indications for adrenaline use including:

- Hypertension, angina pectoris, heart failure;
- Diabetes mellitus;
- Bronchial asthma;
- Regularly taken medication (TCAs, MAO inhibitors, beta-blockers);
- Pregnancy;
- Narrow-angle glaucoma.

However, prudent avoidance of blocks, or aspirating when using blocks and slow injection, low dosage and staged treatments allows the use of adrenaline in patients

with these conditions. Use of low dose adrenaline LA agents may be used in these cases (Table 5).¹⁶

- Specific systemic complications have been reported with dental local anaesthetics including methaemoglobinemia. Benzocaine should no longer be used. Prilocaine should not be used in children younger than 6 months old, in pregnant women, or in patients taking other oxidizing drugs. The dose should be limited to 2.5 mg/kg. At low levels (1–3%), methaemoglobinemia can be asymptomatic, but higher levels (10–40%) may be accompanied by any of the following complaints: cyanosis, breathlessness, tachycardia, fatigue and weakness.¹⁷

- Drug interactions

- Lidocaine can interact with CNS depressants and with H2 Blocker (PPIs)

- Epinephrine

- Propranolol is the only non-selective beta-blocker reported to have the potential to cause severe hypertension and reflex bradycardia in the presence of epinephrine.

- A significant risk does not appear to be associated with the use of epinephrine and cardio selective beta-blockers.

Many complications or adverse events arise during dental local anaesthetics due to the patient being overly anxious or not well informed. Thus, the LA technique used must address several aspects including:

- Care to recheck medical history at every visit

- Check patient's recent prescription chart (<2 weeks);

- Check patient's blood pressure;

- Care with small patients:

- Children;

- The elderly (sarcopenia is the loss of muscle mass which reduces body mass significantly after 60 years).

- Good pre-operative assessment of medical history and anxiety levels;

- Reassurance/warnings (avoid showing patient the syringe);

- Give the patient feelings of control;

- Distraction;
- Topical LA;
- Place fingertip near region where the needle is about to inject;
- Warm LA cartridges;
- Slow injections are less painful and more effective.¹⁰

A key factor in patient satisfaction is a sense that the care-giver is doing his/herr best and is genuinely concerned that therapy is adequate.¹⁸

<ch1/1>How do we minimise regional complications of LA?

Avoiding failed LA

There are many myths regarding failed LA in dentistry.¹⁹ Local anaesthesia failure is often assumed to be the fault of the clinician due to the general overestimation of the effectivity of block anaesthesia providing pulpal anaesthesia in the mandible. The onset of lip numbness occurs usually within 5-9 minutes of injection and pulpal anaesthesia follows later 15-16 minutes.²⁰⁻²² Slow onset of pulpal anesthesia (after 15 minutes) occurs approximately 19-27% of the time in mandibular teeth and approximately 8% of patients have onset after 30 minutes.²³ Lip numbness does not guarantee pulpal anaesthesia and failure to achieve lip numbness occurs about 5% of the time with experienced clinicians.^{24,25}

Inferior dental blocks are remarkably inefficient at providing pulpal anaesthesia for dental procedures.²⁶⁻²⁸ Malamed stated the rate of inadequate anaesthesia ranged from 31% to 81%. When expressed as success rates, this indicates a range of 19% to 69%.

These numbers are so wide ranging as to make selection of a standard for rate of success for IANB seemingly impossible.¹⁰ There are many other possible components contributing to LA failure including;

- Anatomical variation Flared or broad mandibular rami may require modified IDB technique.²⁹
- Patients who have a poor history to responding to LA.³⁰
- Speed of IDB injection - A slow inferior alveolar nerve block injection (60 seconds) results in a higher success rate of pulpal anaesthesia and less pain than a rapid injection (15 seconds).³¹

- Pathological (infection)^{32,33} Pulpitis is a challenging clinical problem, and can only be overcome by increasing the dose of anaesthetic in the area, with increased accuracy of the placement of the anaesthetic solution.³⁴
- Choice of technique, insufficient dose, poor technique, damaged LA due to poor storage.³⁵

How do we manage failed IDB?

- Giving another inferior alveolar nerve block does not help the patient if they feel pain during operative procedures. The second injection does not provide additional anesthesia—the first injection is just “catching up”.³⁶
 - Increasing the volume to two cartridges of lidocaine or increasing the epinephrine concentration from 1:100,000 to 1:50,000 (20, 21) will not provide better pulpal anesthesia.^{37,38}
 - Use higher concentration agents for block injections is not evidenced to improve efficacy.³⁹⁻⁴¹
 - Specifically articaine compared with lidocaine IDBs has no or limited additional efficacy.^{42,43}
 - Computed techniques do not ad advantage for IDB efficacy.⁴⁴
 - There is increasing evidence that additional injections (buccal infiltration, intraseptal, intraligamental, intra osseous) can enhance and even replace IDBS. Supplemental injections can improve mandibular pupal anaesthesia.³³
 - Recent studies report that giving a buccal infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine after an inferior alveolar nerve block significantly increased success (88%) when compared to a lidocaine formulation (71% success).^{45,46}
- In a study of 182 patients 122 achieved successful pulpal anesthesia within 10 minutes after initial IANB injection only 82 experienced pain-free treatment. Additional articaine buccal infiltration (ABI) and Intraosseous (IO) allowed more successful (pain-free) treatment.⁴⁷
- **IANB + ABI 84% pain free RX**
 - **IANB + IO 68% pain free Rx**
 - **IANB + PDL 48% pain free Rx**

- **IANB alone 32% pain free Rx**

- The addition of intraligamental injections may assist in extractions.^{48,49}

However, intraligamental injections are unlikely to be as effective as IDB alone for other dental procedures.

- The addition of the intraosseous injection after an inferior alveolar nerve block, in the first molar, will provide a quick onset and a high incidence of pulpal anesthesia (approximately 90%) for 60 minutes. Clinically, the supplemental intraosseous injection works very well but systemic cardiac effects are related to the 'intravenous' nature of this injection.⁵¹⁻⁵³

There is no evidence supporting using direct or indirect Halstead IDB technique or the improved efficacy of using Gow Gates or Akinosi techniques. The main issues appear to be the overestimation of the efficacy of IDBs in general, impatience and lack of awareness that one must wait over 15 minutes for maximum efficacy of a lidocaine block, in addition the lack of use of alternative techniques that provide improved pulpal anaesthetic rates for anterior teeth.

<ch1/1>**How do we minimise regional complications of LA?**

Most of these complications can be avoided by careful technique and avoidance of intravascular injections but even when clinicians use the utmost care, by aspirating before the injection and noting anatomical landmarks, intra-arterial injections can occur during inferior alveolar nerve blocks.⁵⁴ Fortunately, permanent damage to nerves, facial and oral tissues, and eyes is rare. Possible regional complications related to IDBs include;

- Facial palsy likely due to poor IDB technique with too deep or superior injection through the coronoid process into the sheaths of the parotid gland through which the facial nerve travels.⁵⁵
- Tissue trauma-haematoma trismus. In patients who have coagulopathies or platelet malfunction avoidance of block injections is advisable but occasionally unavoidable.

- Fracture of the needle is more likely to occur with 30 gauge needles, using needles too short leaving no additional space between the Hub and tissues and pre bending of the needle prior to injection.^{56,57}
- Ophthalmic complications.⁵⁸
- Nerve injury Nerve injury related to IDB injections may cause permanent neuropathy in lingual and inferior alveolar nerves often associated with combined numbness, paraesthesia and neuropathic pain. Though LA related permanent nerve injury is rare (approximately 1 in 52-7K IDBs) once the injury occurs approximately 75% may resolve but the remaining 25% are untreatable. Most patients with trigeminal nerve injuries experience chronic pain in their lip teeth and gums or tongue and gums depending on which nerve is damaged. This is a lifelong burden that these patients find difficult to accommodate to especially when they were never warned about the possible risk. The risk of nerve injury can be mitigated by altering the block technique or by avoiding block anaesthesia altogether. The risk factors for nerve injury related to dental anaesthesia are listed in Table 6

The incidence of persistent neuropathy related to dental IDBs is rare, estimated to be between 1 in 14K temporary and 1 in 52K permanent (25% permanent),⁵⁹ 1:26,762 and 1:160,571,⁶³ 1 in 27,415 cases,⁷⁴ 1 in 785,000 injections, to 1 in 13,800,970.⁶⁶ The majority of nerve injuries are painful in patients seeking care, consistent with other surgical sensory neuropathies leading to a condition known as chronic post-surgical pain. Unfortunately for these patients the unforeseen complication of routine dental care leads to life changing orofacial pain with subsequent significant functional and psychological sequelae.

Management There is no evidenced based treatment for these nerve injuries we have to sit and wait whilst caring for the patients. If pain is caused during an IDB arrange to contact the patient the next day to exclude persistent neuropathy (pain, numbness and or altered sensation), reassure them that 75% recover, medical intervention including NSAIDs, Vitamin B and steroids as used for spinal iatrogenic nerve injuries may be effective in reducing neural inflammation and irritation but there is no evidence to

support this aside from patients being reassured that their clinician is trying to help them.

Should patients be warned of possible rare nerve injuries related to dental LA? Based upon the *Montgomery* ruling clinicians must now ensure that patients are aware of any "material risks" involved in a proposed treatment, and of reasonable alternatives, following the judgment in the case *Montgomery v Lanarkshire Health Board*. This is a marked change to the previous "Bolam test", which asks whether a doctor's conduct would be supported by a responsible body of medical opinion. This test will no longer apply to the issue of consent, although it will continue to be used more widely in cases involving other alleged acts of negligence. Thus one has to question when would a permanent burning tongue or elicited neuralgic pain of the face caused whenever to eat, kiss, speak or go out in the cold is not material to a patient? Suggested routine consent was suggested in the US in 1939.⁷² In Germany there is already a legal precedent to warn all patients undergoing dental LA of possible nerve injury and any patient undergoing spinal or epidural injections in the UK must warn patients of possible permanent motor or sensory nerve injuries in 1 in 57K.⁷³

Thus, prevention of LA nerve injuries is paramount most effectively achieved by avoiding block anaesthesia. Dentistry is the ONLY healthcare profession taught to aim for nerves blindly during block injections! There is increasing pressure to use ultrasound neural location to minimise systemic toxicity and nerve injuries as practiced in regional block anaesthesia elsewhere in the body. Other strategies would include avoiding risk factors (Table 6⁵¹⁻⁷⁹) but mainly avoid block anaesthesia and using infiltration techniques instead.

<ch1/1>What is wrong with our current practice and how can we do better?

Proposed Tailored smart LA practice

- What technique?
- What Agent?
- What LA volume?

The limitations of IDB in providing swift mandibular pulpal anaesthesia is recognised and recent evidence supports the use of infiltration mandibular dentistry.

Interestingly, for decades dentists have routinely undertaken maxillary dentistry with infiltrations accepting that nerves within bone are accessible to submucosal local anaesthetic techniques. With respect to maxillary infiltration anesthesia, some studies have found 4% articaine to be more effective than 2% lidocaine for lateral incisors but not molars,⁷⁴ while others reported no clinical superiority for this injection.^{75,76} A recent randomized controlled trial found a statistically significant difference supporting use of 4% articaine in place of 2% lidocaine for buccal infiltration in patients experiencing irreversible pulpitis in maxillary posterior teeth.⁷⁷

As mentioned previously nerve blocks are related to nerve injury and there are no indications to use palatal, incisal or infraorbital nerve blocks for dentistry except in very rare exceptions; for example spreading infection from canines or premolar use of block anaesthesia will prevent the need for GA drainage and extractions. Several studies report the lack of indications for palatal block injections.^{78,79} There is increasing evidence that additional injections (buccal infiltration, intraseptal, intraligamental, intra osseous) can enhance and even replace IDBs.^{32,35,47,77} Lidocaine infiltration is likely as effective as articaine for maxillary dentistry.⁸⁰ A recent systematic review highlighted that there is no benefit in using articaine infiltration for maxillary dentistry but articaine is 3.6 more times effective than lidocaine for mandibular infiltration dentistry.⁸¹

<ch1/1>Can articaine 4% infiltration replace lidocaine 2% IANBs for routine dentistry?

Undoubtedly using infiltration and not IDBs improves patient comfort as patients will undoubtedly prefer having full lingual sensation and shorter duration LA anaesthesia after dental treatment.³² Not only are buccal infiltration techniques proving as or more effective than IDBs but intraligamental injections can also be used effectively for exodontia as intraligamental injections are effectively intravascular with more likely systemic effects but in addition there is reported higher post restorative pain levels.⁸²⁻⁸³

<ch1/1>IDBs are unnecessary to treat

- pulpitic mandibular molars in adults,⁸⁴⁻⁸⁵

- for exodontia in adults and children,⁸⁶⁻⁸⁷
- IDBs are unnecessary to treat for implant surgery.⁸⁸ One hundred and twenty patients requiring the placement of a single implant in order to replace a missing first mandibular were randomly allocated to two groups comparing crestal with infiltration. No nerve damage occurred using either anaesthesia types, therefore the choice of type of anaesthesia is a subjective clinical decision. However, it may be preferable to use a low dose (0.9 ml) of subperiosteal anaesthesia, since it is unnecessary to deliver 7.2 ml of articaine to anaesthetise a single mandibular molar implant site.⁸⁹
- IDBS are unnecessary for restorative mandibular care in kids.⁹⁰ However in a recent study of 57 paediatric patients undergoing restorative mandibular treatment reported a higher success and less painful treatment with IANB. There was no statistically significant difference in local analgesia success between articaine and lignocaine when delivered via buccal infiltration.⁹¹

<ch1/1>**Benefit of computerised systems for infiltration techniques**

There is limited evidence to support that computerised infiltration systems are more effective but those regularly using these systems empirically report better patient acceptance and comfort during injections.⁹²

<ch1/1>**What is the best agent?**

Articaine (4-methyl-3-[2-(propylamino)-propionamido]-2-thiophene-carboxylic acid, methyl ester hydrochloride) is a unique amide LA in that it contains a thiophene, instead of a benzene, ring. The thiophene ring allows greater lipid solubility and potency as a greater portion of an administered dose can enter neurons. It is the only amide anaesthetic containing an ester group, allowing hydrolysis in unspecific blood esterases. About 90% of articaine metabolises quickly via hydrolysis in the blood into its inactive metabolite articaic acid, which is excreted by the kidney in the form articaic acid glucuronide. Its metabolism is age dependent, where clearance and volume of distribution decreases with increasing age. The elimination serum half-life of articaine is 20 minutes and of articaic acid is 64 minutes.⁹³⁻⁹⁵ articaine at different three comparative lidocaine concentrations provide more effective in providing mandibular pulpal anaesthesia,⁹⁶ however, articaine is 3.6 times more effective for

mandibular infiltration dentistry⁹⁷ and a recent study demonstrated that 2% articaine is as effective as 4% articaine using IDB for mandibular dental extraction in adults.^{98,99} In summary more research is needed before recommending replacing 4 with 2% articaine for all dental procedures

Concentration of epinephrine may be reduced from 1in 100 to 1in 200 and equally effective for third molar extraction¹⁰⁰ and epinephrine concentration of 1 in 400 may only be required for paediatric extractions using 4% articaine.¹⁰¹

So is the future agent for dental anaesthesia 2% articaine with 1: 200 -400K epinephrine for all LA techniques and dental procedures in Adults? Could we use Epinephrine Free LA for paedodontic dentistry? Further research is needed

<ch1/1>What LA volumes should we be using?

The most common LA cartridge volume used worldwide is 1.8ml,¹⁰² Dentists in France and Japan use only 1ml cartridges and the commonwealth 2.2ml cartridges.Dictation of LA volume should be diameter of nerve and accuracy of technique in 40 procedures in 32 patients Buccal Infiltration Average LA volume 0.59ml with 97.5% effective pain control.¹⁰³

Infiltration techniques require significant less LA Volume compared with block techniques (0.6-9ml), Gow Gates only block anaesthesia technique where full cartridge 1.8 -2.2ml is recommended and infraorbital LA bloc requires 1.8-2.2 ml.¹⁰⁴

Figure 4 Volume recommendation for maxillary local anaesthesia in dentistry taken from *Malamed SF Techniques of maxillary anaesthesia in Handbook of local anaesthesia Malamed SF 6th edition Mosby Elsevier 2013, St Louis Page 223.*¹⁰⁴

Recommended Volumes for Maxillary Injection Techniques	
Technique	Volume (ml)
Supraperiosteal (infiltration)	0.6
Posterior superior alveolar (PSA)	0.9 to 1.8
Middle superior alveolar (MSA)	0.9 to 1.2
Anterior superior alveolar (ASA)	0.9 to 1.2
Anterior middle superior alveolar (AMSA)	1.4 to 1.8
Platal approach-anterior superior alveolar (P-ASA)	1.4 to 1.8
Greater (anterior) palatine	0.45 to 0.6
Nasopalatine	0.45 (max)
Palatal infiltration	0.2 to 0.3
Maxillary (V ₂) nerve block	1.8

Figure 5 Volume recommendation for mandibular local anaesthesia in dentistry taken from *Malamed SF Techniques of maxillary anaesthesia in Handbook of local anaesthesia Malamed SF 6th edition Mosby Elsevier 2013, St Louis Page 223.*¹⁰⁴

Recommended Volumes for Mandibular Injection Techniques	
Technique	Volume (ml)
Inferior alveolar (IANB)	1.5
Buccal	0.3
Gow-Gates (kind of IANB)	1.8
Vazirani-Akinosi (kind of IANB)	1.5 to 1.8
Mental	0.6
Incisive	0.6 to 0.9

Thus the continued use of 2.2ml cartridges should be questioned and changed to 1.8ml cartridges which would improve patient safety and likely impact minimally on repeated injections

The future interest is the possibility of development of newer improved agents (sensory blocking agents only) and devices and techniques for achieving profound sensory anesthesia. A nasal spray (<http://clinicaltrials.gov/ct2/show/NCT01302483>) has shown to anesthetize maxillary anterior six teeth is set to be tested in an FDA Phase 3 trial, which will assess the spray's effectiveness compared to the current "gold standard" treatment - painful anesthesia injections. Buffering of acidic local anaesthetics to more neutral physiological pH allows for speedier LA onset and is already in use in the US. Another development is a syringe micro vibrator (SMV),¹⁰⁵ a new device being introduced in dentistry to alleviate pain and anxiety of intraoral injections.

<ch1/1>Summary

A radical change in practice is required with regard so many aspects of patient safety based upon current evidence whilst acknowledging further research would be ideal. With the current research legislation, undertaking simple efficacy studies of existing commonly used LA agents is prohibitively expensive and unlikely to be funded by pharmaceutical companies, limiting the provision of future robust supportive research. Infiltration LA for implantology is a good example where common sense and application of optimal technique has occurred without robust evidence base providing safer more effective patient care.

- A tailored approach to dental local anaesthesia should be recommended to prevent the continued unnecessary use of IDBs when infiltration anaesthesia is likely more effective for most dental procedures. **Tailored LA is dictated by the site and procedure See Figure 3 summarising the optimal anaesthetic techniques**
- The lack of safety giving blind block injections with likely systemic and local complications (especially nerve injury) may be considered 'indefensible'.
- IDBs should be prescribed in limited cases when indicated (see Tailored LA below)
- Consent for LA, in the light of Montgomery consent recommendations, all patents should be routinely warned of a risk of nerve injury when routinely undergoing Dental local anaesthesia as they are already in Germany and in the UK related to epidural or spinal injections
- Reduction of epinephrine levels is likely possible for most dental procedures also improving patient safety and minimising systemic effects and reducing problems in medically compromised patients
- Revisitation of the required cartridge volume is necessary and recommendation for the use of 1.8ml versus 2.2ml cartridges will improve patient safety

<ch1/1>References

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Table 1 Adverse effects are usually caused by high plasma concentration of either LA drug or adjunctive content resulting from;

Vasoactive adjunctive agents are added to

- Delayed absorption of LA
- Reduction of the systemic plasma levels of the LA
- Prolongation of the duration of action of the LA
- Reinforcement of the intensity of the LA's effects
- Not dependent on concentration
- Reduction of local blood perfusion

Table 2 Maximum doses of local anaesthetic agents

Drug	Max dose	1/10 th cartridge
2% lidocaine	4.4mg/kg	3.6 - 4.4mg
2% mepivacaine	4.4mg/kg	4.0mg
3% mepivacaine	4.4mg/kg	6.0 mg
3% prilocaine	6.0mg/kg	6.6mg
4% prilocaine	6.0mg/kg	8.0mg
4% articaine	7.0mg/kg	6.8 - 8.0mg

Table 3 Lidocaine toxicity	
At serum levels patients may complain of;	
•	1-5 mcg/mL
–	Tinnitus
–	Lightheadedness
–	circumoral numbness
–	Diplopia
–	metallic taste
–	may complain of nausea and/or vomiting, or they may become more talkative.
•	5-8 mcg/mL
–	nystagmus, slurred speech, localized muscle twitching, or fine tremors may be noticed. Patients also have been noted to have hallucinations at these levels.
•	8-12 mcg/mL
–	focal seizure activity occurs; this can progress to generalized tonic-clonic seizures. Respiratory depression occurs at extremely high blood levels (20-25 mcg/mL) and can progress to coma.

Table 4 Absolute medical contraindications for LA include;	
• Pheochromocytoma	adrenaline producing tumour of the adrenal gland
• Hyperthyroidism	Elevated levels of thyroxine which lead to sensitisation of adrenaline receptors
• Tachycardic arrhythmias	Unstable ventricular fibrillation
• Sulphite allergy	Anaphylactic reaction

Table 5 Low dose adrenaline LA agents may can be used in these cases

Articaine 4% with adrenaline 1: 400,000	12.5 ml *
Articaine 4% with adrenaline 1: 200,000	8 ml *
Articaine 4% with adrenaline 1: 100,000	4 ml *
Articaine 4% without adrenaline	7 ml *
Mepivacaine 3% without adrenaline	10 ml *
Mepivacaine 2% without adrenaline	15 ml *

Table 6 ^{32, 59-79} Risk factors for nerve injury related to dental local anaesthesia

Block anaesthesia	59
Lingual nerve > IAN	60
Blind block injections There is criticism of teaching the use of blind injections in dentistry	61-63

• Technique or Anatomy?	No evidence that direct Halstead causes more lingual nerve injuries than indirect technique
Concentration of LA agent	59, 60, 64-71
Speed of injection	
Multiple injections	59
Severe pain on injection	60% more likely to experience persistent neuropathy ⁵⁹
LA Agent toxicity	Increasing toxicity at same concentration Bupivacaine > Mepivacaine > Prilocaine > Lidocaine > Articaine
• Type of vasoconstrictor? • Sedated GA • Lack LA aspiration	No evidence No evidence No evidence

Figure 3 Summarising Mandibular LA infiltration techniques

Infiltration dentistry is dependant upon the site and procedure

Maxillary dentistry can be performed entirely using Lidocaine 2% with adrenaline for all procedures
Buccal infiltration with intra-septal injections
No additional benefit using 4% Articaine
No palatal or incisal blocks are indicated

Posterior mandibular molar Endodontic procedures may require IDBs or higher techniques (Gow Gates or Akinosi)



Mandibular 7s and 8s for perio, restorations or implants

Articaine 4% buccal infiltration and Lidocaine 2% lingual infiltrations OR for extractions intraligamental
If fails may need lidocaine IDB

Mandibular 1st molars for perio, restorations or implants

Articaine 4% buccal +/- Lidocaine 2% crestal or lingual infiltration s OR for extractions add lidocaine lingual of intra-ligamental

Mandibular premolars, canines incisors for perio, restorations or implants

Articaine buccal infiltration (incisal nerve block using 30% cartridge) adjacent not in the mental foramen and massage over region. If fails repeat or add crestal or lingual infiltration OR for extractions, intra-ligamental

Illustration modified from figure courtesy of Andrew Mason University Dundee